PROCESS AND ARRANGEMENT FOR REPLACING INTRA-FIBER LIQUID IN FIBERS WITH A REPLACEMENT LIQUID

The present invention is generally directed to a process and an arrangement for replacing intra-fiber liquid in fibers with a replacement liquid.

BACKGROUND OF THE INVENTION

It is well known that cooked or digested materials such as wood pulp fibers or textile fibers such as cotton fibers and other fibers with pores in their fiber walls, are containing various chemicals or substances that are less desirable or eligible. To get rid of or at least lessen their contents various methods of washing fibers have been used.

The original method used for fiber washing is dilution – extraction. It consists of diluting a fiber slurry with a weaker liquid and subsequently thicken it and raising the consistency.

Diffusion has also been used for washing fibers where wash liquid is mixed with the fibers and at some time later, up to a few hours, is displaced.

Vacuum washers have also been used where the liquid content of the fibers are extracted by an applied vacuum while being subsequently replaced by a wash liquid.

Another method is by using pressure washers. The principle is to apply mechanical pressure on the fiber cake using screws, rolls or a horizontal belt or the like. The thickness of the fiber cake is gradually reduced and the liquid is expressed.

Due to their special nature, fibers also contain liquid inside the fiber wall and also in the lumen. This liquid is henceforward called intra-fiber liquid. So far, the methods used to eliminate the liquid in fiber cakes have only aimed to substitute the liquid contained in pores between the fibers, henceforward called inter-fiber liquid, and not the substantial amount of intra-fiber liquid. To get rid of a substantial amount of the intra-fiber liquid very high pressures are needed. A desired consistency is well over 40 %. This level is usually depending on the type of fiber used. In the state of art sufficiently high pressures have for different reasons not been used. High energy consumption and excessive stress in the machinery used are probable reasons. This has also led to that the liquid in the fiber wall pores and lumen have not been the object of attention for the professionals in the field. With today's technology it is however possible to build washers which manage high strain without breaking. Since the content of contamination such as lignin fragments in the fiber wall is so

significant there is much to gain to get rid of this content or at least significantly reduce it. This will provide a pulp of higher and more uniform quality.

Thus it is an object of the present invention to get rid of or significantly reduce the content of contaminating material not only in the area between the fibers in a fiber cake made of cellulosic, textile, or other fibers, but also in the fiber wall pores and inside the lumen and replace this liquid with a replacement liquid.

This is achieved according to the present invention by a process having the following steps; compressing the fiber cake to such a degree that a substantial quantity of the intra-fiber liquid is expressed into the space between the fibers and partially out of the fiber cake, forcibly supplying the replacement liquid to the fiber cake during the compression into the space between the fibers and thus removing the intra-fiber liquid from the space between the fibers, and letting the fibers expand while supplying additional replacement liquid which is thus further absorbed by the expanding fibers.

It is in another preferred embodiment of the invention suggested that the replacement liquid is cleaner liquid.

In many cases it is interesting to further treat the fibers with different substances. To introduce them into not only the area between the fibers but also in the fiber wall and lumen would be a great advantage as it will provide a pulp fibers of higher and more uniform quality and fiber properties previously not possible.

Thus it is also an object of a preferred embodiment of the present invention to introduce substances for treatment of the fibers not only into the area between the fibers in cellulosic, textile or the like fibers but also into the fiber wall and lumen.

It is in another preferred embodiment of the invention thus suggested that the replacement liquid contains chemical treating agent.

It is in another preferred embodiment of the invention suggested that the replacement liquid is acid or basic for fast acid or base treatment of the pulp fibers.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains bleaching chemical.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains delignifying agent.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains process catalyst.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains chelating agent.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains fluorescent tracer.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains metal ions.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains cationic or anionic polymer.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains dying substance to dye the fibers.

It is in another preferred embodiment of the invention suggested that the replacement liquid contains inorganic substance.

The object is also achieved according to the present invention by an arrangement comprising a device for compressing the fiber cake to such a degree that a substantial quantity of intra-fiber liquid is expressed to the space between the fibers and partially out of the fiber cake, a first device for forcibly supplying the replacement liquid to the fibers during the compression and a second device for supplying the replacement liquid immediately after the device for compression arranged in an expansion area where the fibers are allowed to expand after the compression while absorbing the replacement liquid.

It is in another preferred embodiment of the invention suggested that the device for compressing the fibers comprises a rotating compression roll and a press arranged opposite the compression roll with a press nip in which the fibers are fed and the device for forcibly supplying the replacement liquid to the fibers during the compression is a compressible fabric with liquid permeability only in the thickness direction arranged as a moving closed loop in at least partly contact with the compression roll where at least a part of the closed loop in the press nip is in contact with the compressed fibers.

It is in another preferred embodiment of the invention suggested that the device for compressing the fibers comprises a rotating compression roll and a press arranged opposite the compression roll with a press nip in which the fibers are fed and the device for forcibly supplying the replacement liquid to the fibers during the compression comprises radial holes in the compression roll and a pressurized replacement liquid container arranged in the compression area to supply pressurized replacement liquid through the holes from the inside of the compression roll into the fibers in the compression area.

It is in another preferred embodiment of the invention suggested that the second device supplying the replacement liquid is a trough which has a lower opening at an outlet from the device for compressing the fibers.

It is in another preferred embodiment of the invention suggested a system where more than one arrangement are arranged in series.

It needs to be mentioned that the word liquid in this application should be interpreted rather broad and not only mean liquids as such. Thus it is our meaning that it also should include suspensions, dispersions and the like.

Above and other objects of the present invention will appear from the following description of species or forms of embodiment, and from the accompanying drawings.

In the drawings

Fig. 1 is a schematic side view of an arrangement according to the present invention;

Fig. 2 is a schematic side view of a second embodiment of an arrangement according to the present invention;

Fig. 3 is a schematic side view of a third embodiment of an arrangement according to the present invention;

Fig. 4 is a schematic side view of a fourth embodiment of an arrangement according to the present invention;

Fig. 5 is a view of part of the embodiment showed in figure 4;

Fig. 6 is a graph showing the intra-fiber and inter-fiber liquid content of fibers as a function of the compression pressure;

Fig. 7 is a schematic flow chart of the process of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Figure 7 is illustrating a process according to the invention having the following steps; compressing a fiber cake to such a degree that a substantial quantity of the contaminated intra-fiber liquid is expressed to the space between the fibers and partially out of the fiber cake. At the same time a replacement liquid is forcibly supplied to the fiber cake during the compression and displacing the intra-fiber liquid from the space between the fibers. This means that the residual contaminated liquid is greatly diluted and getting even more so when in an expansion phase the fibers expand while supplying additional replacement liquid which liquid is thus further absorbed by the expanding fibers. The whole process means that an exchange or replacement has taken place where the replacement liquid has replaced the

contaminated liquid not altogether but in such a degree that the content of the contaminant in the treated fibers is diluted in a high degree.

According to figure 1, a device according to the present invention generally comprises a belt or wire 1 on which a fiber cake 12 is transported along a predestinated route by motor-driven transport rolls 2 and 3 arranged in parallel with and on each side of a compression roll 4. The compression roll 4 is directly or indirectly driven by a motor. The compression of the fibers takes place between the rotating compression roll 4, which is transversally arranged on the side of the wire 1 where the fibers are placed, and a shoe or roll press 5 arranged on the opposite side of the wire 1 from the compression roll 4 in such a manner that a press nip results where the fibers are compressed and deliquefied. The compression is among other things depending upon how close the compression roll 4 and the press 5 are to each other, i.e. the size of the press nip. Since the compression roll 4 is arranged slightly lower than the transport rolls 2, 3, the wire 1 with the fiber cake is wrapped along a section of the compression roll 4. Due to this roll wrap there is some deliquefying of the fibers before the main compression area which is the press nip between the compression roll 4 and the press 5. A compressible fabric 6 is arranged as a closed loop on the envelope surface of the compression roll 4 to be rotated together with the roll 4 between it and the fiber cake. The fabric 6 is permeable to liquid by way of pores arranged in its thickness direction resulting in a permeability in the thickness direction exclusively. Immediately after the oppositely arranged compression roll 4 and the press 5 a replacement liquid trough 7 is arranged. The trough 7 has a lower opening in its bottom through which the compressible fabric 6 is transported and thus being compressed expands and sucks up replacement liquid. This "liquid filled" area of the compressible fabric is then by way of the rotation of the compression roll 4 transported to the beginning of the roll wrap area and further on to the compression area again where the replacement liquid is pressed out of the pores and into the fiber cake. The replacement liquid is thus displacing the contaminated liquid and at the same time starting to be absorbed by the fiber wall pores and the lumens by way of convection. The wire 1 with the compressed fibers is transported through the lower opening 13 of the trough 7 just after the compression roll 4 and being relieved from the compression pressure, the fibers expand while sucking up even more of the replacement liquid from the trough 7. This expansion phase reduces the concentration of the contamination in the fiber cake both between the fibers and in the fiber wall and lumen as the replacement liquid eventually finds its way there through diffusion. The expansion of the fiber cake usually takes more than 0.5 seconds. To maximally make use of this time it is preferred if the time the fiber cake is in contact with the

replacement liquid in the trough is more than 0.5 seconds. To further reduce the contamination content in the fiber cake a second step or even more steps, of this compression-expansion process could be used in which two or more arrangements according to the invention are arranged in series. This would make it possible to further process the fibers supplying different kinds of replacement liquids for different purposes such as washing, bleaching and so on in a system. Suggestions as to what kinds of replacement liquids are possible to use are made later in this description.

Figures 2 and 3 disclose embodiments of the present invention similar to the embodiment showed in figure 1. In these embodiments the trough 7 is substituted by a replacement liquid reservoir 14 defined by a part of the interior of the closed loop of the compressible fabric 6 and a part the envelope surface of the compression roll 4. This reservoir 14 is in figure 2 arranged just before the closed loop goes into contact with the compression roll 4 and in figure 3 after the closed loop leaves contact with the compression roll 4. The replacement liquid is added to the inside of the closed loop. This arrangement has the advantage that the pores of the compressible fabric 6 are filled from the inside, preventing the occurrence of air in the pores which would hinder the flow out of the pores in the compression phase.

A further improvement in these embodiments is a second reservoir 16 defined by a part of the exterior of the closed loop of the compressible fabric 6 and a flow restrictor 15 which forms a narrow slit with the fabric in the bottommost part of the reservoir 14. The flow restrictor collects the liquid that flows through the compressible fabric 6 and avoids unnecessary flow of replacement liquid. This second reservoir 16 is in the embodiment of figure 2 arranged just before the closed loop goes into contact with the compression roll 4 and in figure 3 after the closed loop leaves contact with the compression roll 4. Even though it is not shown in the figures it is of course possible to include a trough 7 in these embodiments just like the trough 7 in the embodiment shown in figure 1.

In a different embodiment of the invention according to figure 4 and 5 the compression roll 4 is substituted for a compression roll 4a which is formed as a roll shell with radial holes 8 in the same manner as in the compressible fabric 6 in the first embodiment. The compressible fabric is in this way superfluous. A pressurized replacement liquid container 9 supplies the liquid to the compressed fiber cake in the compression area in the press nip while the replacement liquid trough 7 is still present to supply liquid during the expansion phase. The press 5a can in this case also be of a shoe press or roll press type. Indicated in figures 2 and 3 are a shoe press comprising an impermeable shoe press belt 10. The belt 10 is moving

through the container 9 at the same speed as the compression roll 4a. In the compression area the belt 10 is on the side not in contact with the wire 1 influenced by a support pressure and thus acting as a counter support for the forces applied by the compression roll 4a while also balancing pressure from the pressurized replacement liquid container 9 on the compression roll 4a. This support pressure is in this embodiment supplied by a pressurized liquid, preferably hydraulic oil, in a chamber 11 closed by the belt 10.

The liquid in the replacement liquid trough 7 and supplied by the first device for forcibly supplying the replacement liquid is usually cleaner liquid but can in yet another alternative embodiment of the invention contain chemical treating agents. Such treating agents can be acid or basic liquid for the acid or base treatment of the fibers, inorganic substances, bleaching chemicals, process catalysts, chelating agents, tracer substances such as fluorescent substances, metal ions for substituting e.g. Ca-ions in the fibers for Na- or Mg-ions, and cationic polymers to prevent release of anionic substances from the fibers or anionic polymers to get a bulking effect on the fibers (including native polymers).

Figure 6 discloses a graph showing the intra-fiber liquid and inter-fiber liquid content of fibers as a function of the compression pressure. The graph is taken from Laivins, G. V., Scallan, A. M. (1993): "Removal of water from pulps by pressing- Part 1: Inter- and Intra-wall water", Tappi Engineering Conference, 741-747 and clearly shows that the instant effect on the content when a pressure is applied mostly influence the inter-fiber content. At between 0.5 and 1.0 MPa the removed intra-fiber liquid is finally becoming dominant over the inter-fiber liquid. This usually corresponds to a dryness (consistency) of between 30 and 40%. The real impact of the compression on the liquid content in the fiber wall is thus only obvious at higher pressures or dryness percentages.

The operation of the described device is henceforward explained (see figure 7). Fibers with contaminants are fed onto the belt or wire 1 as a fiber cake. The wire 1 with the fiber cake is transported by the transport rolls 2 and 3 preferably as a continuous conveyor. When the wire 1 and the fiber cake are coming into contact with the compression roll 4 with the fabric 6 the fiber cake is thus pre-deliquefied somewhat by the roll wrap caused by the endless wire 1 and fiber cake being wrapped around a sector of the compression roll 4. The fiber cake is thereafter transported into the main compression area of the press nip between the compression roll 4 and the press 5. There liquid is pressed out of the fibers and the fiber wall pores and fiber lumens and partially out of the fiber cake. At the same time the fabric 6 is compressed and replacement liquid in its pores is pressed out and to a large extent is pressed through the fiber cake. This means that the fiber cake during the compression at the same time

is fed replacement liquid that washes through it and displaces the contaminated liquid between the fibers released from the fiber walls. The press nip is such that the compression corresponds to a consistency of well over 40%, preferably over 50% at which a substantial amount of the intra-fiber liquid is removed. As soon as the fiber cake has passed the press nip it is transported through the opening in the bottom of the replacement liquid trough 7. Since the pressure on the fiber cake 12 is released, the fibers expand and absorb additional replacement liquid.